Computational Reconfigurable Imaging Spectrometer (CRISP)

Completed Technology Project (2017 - 2019)

Project Introduction

Spaceborne infrared spectral imagers and sounders provide critical data for a wide range of Earth science applications, such as weather, climate, air quality, and land/water usage. For example, hyperspectral sounders such as Atmospheric Infrared Sounder (AIRS) and the Cross-Track Infrared Sounder (CrIS) observe the Earth's atmosphere with dense spectral coverage, enabling significantly improved weather forecasts and unprecedented measurements of atmospheric composition. In addition, several proposed or existing multispectral imagers such as HyspIRI contain thermal infrared channels, with diverse applications, including land surface imaging. Despite the high value of such infrared imaging spectrometers, high cost and complexity have limited the number of fielded instruments, and dramatically increased the impact of losing any one instrument. Longwave instruments in particular require significant size, weight, and power (SWaP) due to the need for cryocooling, with the cost of existing instruments typically in the hundreds of millions of dollars. As a result, revisit intervals for instruments in low Earth orbit are typically no greater than 12 hours, limiting observations of dynamic phenomena such as severe weather events. As noted in the 2007 Decadal Survey, the cancelation of geostationary hyperspectral sounding from GOES-R led to a significant loss of planned spatial and temporal coverage. To address this, we propose Computational Reconfigurable Imaging Spectrometer (CRISP), a new imaging spectrometer suitable for hyperspectral and multispectral missions. The design of this system will enable high performance from smaller and less-expensive components such as uncooled microbolometers, and thus be more suitable for small satellites that can be deployed in constellations. CRISP is a novel design that exploits platform motion, dispersive elements, and coded sensing techniques to make a time series of encoded measurements of the optical spectrum at each pixel. This encoding is inverted using specialized processing to recover the spectrum. The proposed effort will demonstrate significant sensitivity and other advantages over existing imaging spectrometer designs, enabling miniaturization and improved area coverage. Spectral and spatial resolution and coverage can be traded off with a simple configuration change to encompass multiple mission types. As a particular example, the effort will demonstrate that an uncooled CRISP system can provide longwave sensitivity and spectral resolution comparable to AIRS for relevant channels, with improved spatial resolution that may enhance boundary layer observation and complement existing midwave Cubesat sounder efforts. Multispectral applications with more demanding spatial requirements will be demonstrated as well. The goal of the proposed effort is to improve the technology readiness of CRISP by validating it in a laboratory, designing and building a brassboard, and demonstrating a brassboard in outdoor and environmental testing. We assess CRISP to currently be at a TRL of 3, as the theory has been formulated and simulated, but, to date, only a partially functional breadboard demonstration has been instantiated in hardware. In Year 1, we propose to build a fully functional breadboard, and demonstrating the principles and theoretical sensitivity

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

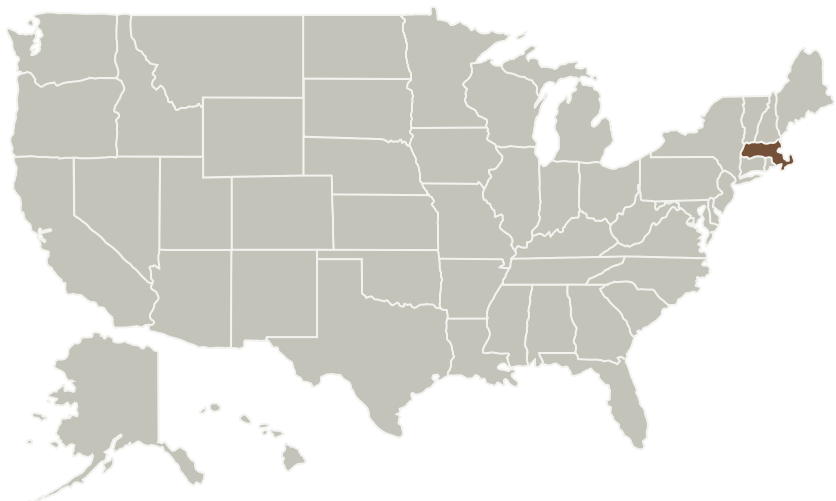
Massachusetts Institute of Technology (MIT)

Responsible Program:

Advanced Component Technology Program

enhancement described in the main proposal text. We will also develop the processing algorithms. This system will satisfy the criteria for a TRL of 4. In year 2, we propose subject it to thermal tests, along with functional tests on an outdoor rotating platform. This system will satisfy the criteria for TRL5.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Massachusetts Institute of Technology(MIT)	Lead Organization	Academia	Cambridge, Massachusetts
Massachusetts Institute of Technology Lincoln Laboratory(MIT-LL)	Supporting Organization	R&D Center	Lexington, Massachusetts

Primary U.S. Work Locations
Massachusetts

Project Management

Program Director:

Pamela S Millar

Program Manager:

Amber E Emory

Principal Investigator:

Adam B Milstein

Co-Investigators:

Ryan Sullenberger
David M Pronchick
Charles M Wynn
Corrie V Smeaton
Yaron Rachlin
Melissa M Pike

Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.1 Remote Sensing Instruments/Sensors
    └ TX08.1.1 Detectors and Focal Planes

Target Destination
Earth